PACKING AND SHIPPING MECHANICALLY HARVESTED LETTUCE

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INTRODUCTION

Western iceberg lettuce accounts for approximately 20 percent of all carlots of fresh fruits and vegetables shipped from California, constituting the largest volume of a single perishable commodity shipped out of State. Lettuce shipments have increased by approximately 17 percent between 1968 and 1972.[1]

ARS agricultural engineers have developed a mechanical lettuce harvester,[2] which may be the key element of a handling and marketing system that will enable producers and marketers of lettuce to keep pace with increasing costs. Field tests show that the two-row experimental, mechanical lettuce harvester can harvest about 450 cartons per hour (24 heads per carton). With present packaging and handling methods, the mechanical harvester is limited by the rate at which the crew on the machine can grade and pack the lettuce.

The purpose of this study was to determine if lettuce could be handled in large containers, and the effect of this handling on lettuce quality. A system to increase the product flow from the harvester into a shipping container was investigated. This system was based on jumble filling the lettuce into relatively large containers on the harvester. The containers varied in size, holding from 50 to 240 heads, compared with the present 24-head carton.

SUMMER SHIPMENTS, 1973

Procedure

Six shipping tests were conducted to compare the condition of lettuce harvested by the USDA-developed mechanical lettuce harvester with that of hand-harvested lettuce, shipped from the Salinas Valley of California to midwestern and eastern markets. The machine-harvested lettuce was jumble filled in wax-coated boxes 23¼ inches long by 15¾ inches wide by 24 inches deep (fig. 1) (table 1). These jumble-filled boxes were stacked on a 48- by 40-inch pallet, five boxes per layer. As controls, 24 heads of hand-harvested lettuce were place packed in conventional non-waxed cartons, 21¾ inches long by 16½ inches wide by 11¼ inches deep.

Timestudies on the direct labor for cutting, trimming, and packing lettuce were conducted in the field. All lettuce was vacuum cooled in the conventional manner and loaded in railcars. On arrival at terminal markets, the shipping containers were evaluated for damage, and the lettuce was scored for appearance, trim loss, firmness, and crushing and bruising. A scale of 1 through 5 was used to denote defects or acceptability. All data were treated statistically by analysis of variance.

[1] Anonymous. Movement of California fresh fruits and vegetables. Federal-State Market News Service, U.S. Dept. Agr., Agr. Market Serv., Market News Branch. 1972.

[2] Anonymous. Harvesting lettuce electronically. Agr. Res. 22(7):8-11. 1974.

Direct Labor Costs

Timestudies on jumble filling experimental boxes were conducted under experimental conditions, and untrained personnel were used on the mechanical lettuce harvester. Therefore, the times given may represent the maximum. Less time would probably be required if skilled or trained personnel were available. The data for picking and packing lettuce in conventional cartons are based on observations of more than 4,000 cartons of lettuce handled under commercial conditions.

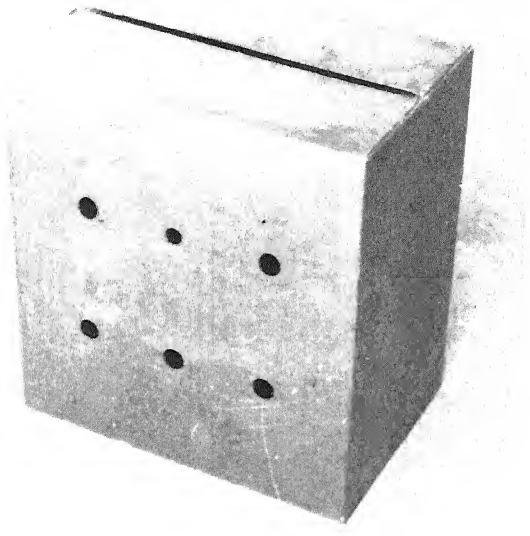

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FIGURE 1.—Wax-coated box used for jumble-filled, mechanically harvested lettuce.

TABLE 1.—*Average net weight, tare weight, gross weight, number of heads, outside dimensions, and volume of jumble-filled boxes of lettuce and place-packed conventional cartons, 1973*

Item	Jumble-filled experimental box	Place-packed conventional carton
Average net weight of lettuce (pounds)	87.5	45.6
Average tare weight (pounds)	7.1	3.4
Average gross weight (pounds)	94.6	49.0
Average number of heads	54	24
Outside dimensions (inches)	23¼x15¾x24	21¾x16½x11¼
Volume (cubic inches)	8788.5	4037.3

Hand-cutting, trimming, and packing 24 heads of lettuce in the conventional carton requires approximately 3¼ man-minutes or 16.3 cents (table 2). To mechanically cut, trim, and pack the equivalent amount of lettuce in the jumble-filled boxes, required about 2¾ man-minutes or about 13.5 cents. These costs are direct labor costs only, and do not include equipment or other costs relating to the mechanical lettuce harvester.

TABLE 2.—*Average direct labor time and costs required to cut, trim, and pack the lettuce in jumble-filled experimental boxes and place-packed conventional cartons, 1973*

Item	Jumble-filled experimental box [1]		Place-packed conventional carton [2]	
	Man-minutes	Cents [3]	Man-minutes	Cents [3]
Driver	1.2	6.1	--	---
Cut	--	---	2.1	10.7
Trim	2.4	12.2	--	---
Pack	2.4	12.2	1.1	5.6
Total	6.1	30.5	3.2	16.3
Per 24 heads	2.7	13.6	3.2	16.3

[1] Average 54 heads per box; calculation does not include turnaround time or costs associated with the harvester.
[2] 24-head carton.
[3] Based on an assumed wage rate of $3/h.

Arrival Condition

The large experimental boxes arrived at midwestern and eastern markets in good condition, with very little compression from overhead weight, even though one shipment was in transit for 2 weeks. There were no container failures, and the large jumble-filled boxes sustained less compression damage than the conventional 24-head carton.

Severe to extreme crushing and bruising of the lettuce were essentially the same (about 5 percent) in the mechanically harvested and conventionally harvested lettuce (table 3)). However, the mechanically harvested lettuce had fewer soft-to-very-soft heads than the hand-harvested, 24-head cartons. In addition, there was less trim loss at the retail level from mechanically harvested lettuce in jumble-filled boxes than from lettuce packed in conventional cartons.

TABLE 3.—*Arrival condition of mechanically harvest lettuce jumble filled in large boxes compared with hand-harvested lettuce place packed in cartons shipped to midwestern and eastern markets in 1973* [1]

Item	Jumble-filled experimental box	Place-packed conventional carton	Item	Jumble-filled experimental box	Place-packed conventional carton
Appearance rating [2]	3.3	3.3	Firmness rating [3]	3.3	3.2
Gross weight (pounds per head)	1.8	1.9	Crushing and bruising [4]	2.3	2.0
Net weight (pounds per head after trim)	1.4	1.3	Heads per cubic foot	9.7	10.5
Trim loss (percent)	22.2	31.6	Weight (pounds per cubic foot)	18.4	22.0

[1] The mean differences between treatments were not statistically significant.
[2] 1 = unsalable, 2 = poor, 3 = fair, 4 = good, 5 = excellent.
[3] 1 = soft, 2 = fairly firm, 3 = firm, 4 = hard, 5 = extra hard.
[4] 1 = none, 2 = slight, 3 = moderate, 4 = severe, 5 = extreme.

WINTER SHIPMENTS, 1974

Procedure

Two shipping tests were conducted to compare the condition of mechanically harvested lettuce jumble filled in experimental containers with that of hand-harvested lettuce packed in conventional cartons, shipped from Imperial Valley, Calif., to midwestern markets. The mechanically harvested lettuce was jumble filled into either: (*a*) Pallet-size bins 47½ inches long by 39½ inches wide by 23 inches deep; or (*b*) nonwaxed boxes 24 inches long by 16 inches wide by 16 inches deep (table 4) (fig. 2).

Each pallet-size bin was placed on a single 48- by 40-inch disposable pallet. Twenty-five nonwaxed, jumble-filled boxes were stacked on each 48- by 40-inch pallet, five boxes per layer. The conventional cartons were not palletized. After packing, the lettuce was vacuum cooled and loaded on trucks. On arrival, the lettuce was evaluated for appearance, trim loss, firmness, and crushing and bruising.

Temperature Management

Studies of cooling rates and transit temperatures for lettuce jumble filled in pallet-size bins and in experimental boxes indicated that the lettuce that had initial temperatures of 65° to 80° F cooled to below 40° in about one-half hour. Comparable temperatures and times were recorded for lettuce cooled in the conventional 24-head carton (fig. 3).

During the 4 days in transit, the temperature of lettuce in the jumble-filled pallet bin rose 2° F,

TABLE 4.—*Average net weight, tare weight, gross weight, number of heads, outside dimensions, and volume of jumble-filled pallet bins, jumble-filled nonwaxed boxes, and place-packed conventional cartons, 1974*

Item	Jumble-filled experimental pallet bin	Jumble-filled experimental nonwaxed box	Place-packed conventional carton
Average net weight (pounds)	418.0	60.0	52.8
Average tare weight (pounds)	[1] 62.0	4.8	3.4
Average gross weight (pounds)	480.0	64.8	56.2
Average number of heads	232	30	24
Outside dimensions (inches)	47½x39½ x23	24x16x16	21¾x16½ x11¼
Volume (cubic inches)	43,153.8	6,144.0	4,037.3

[1] Includes the weight of a 48- by 40-inch disposable pallet.

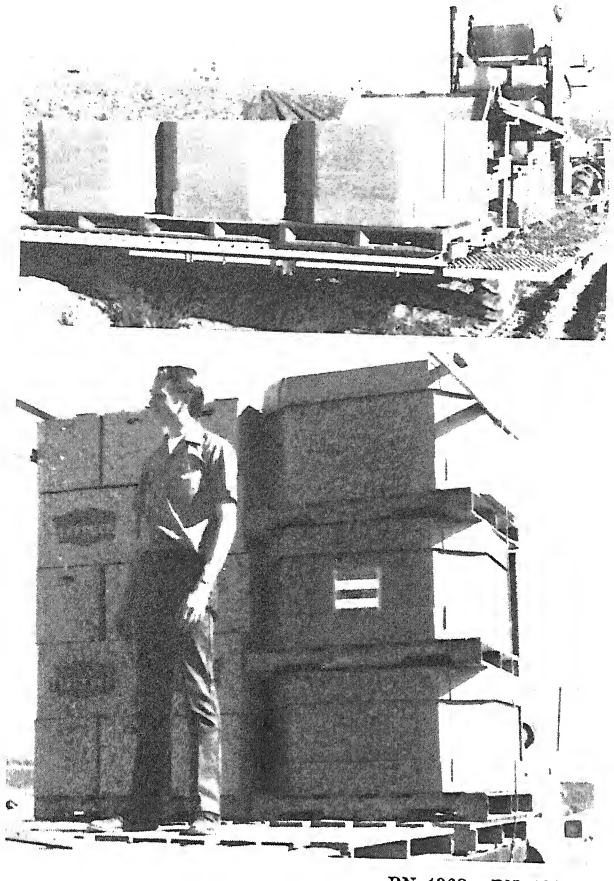

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FIGURE 2.—Top: Pallet-size bins on the USDA's mechanical lettuce harvester. Bottom: Pallet-size bins and nonwaxed boxes palletized and loaded on a field truck.

while temperatures in the other two types of boxes remained constant. This rise in temperature was probably caused by the heat of respiration produced by the lettuce in the unvented bin. Previous studies by Lipton and Barger[3] have

[3] LIPTON, W. J., and BARGER, W. R. MARKET QUALITY OF HEAD LETTUCE IN RELATION TO DELAYS BETWEEN HARVEST AND TEMPERATURE AFTER COOLING. U.S. Dept. Agr., Agr. Res. Serv. ARS 51-5, 14 pp. 1965.

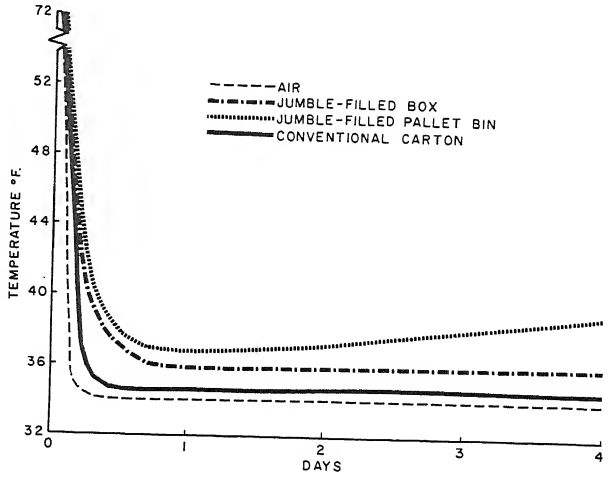

FIGURE 3.—Temperatures of lettuce in jumble-filled experimental boxes, jumble-filled experimental pallet bins, and place-packed conventional cartons during vacuum cooling and transit, 1974.

shown that lettuce quality deteriorates quickly at temperatures above 38°. The lettuce in this test was not above 38° for any appreciable time, but for longer transit times shipping lettuce in nonventilated containers would not be advisable.

Arrival Condition

The pallet-size bins arrived at the midwestern market in excellent condition without any appreciable container damage.

The mechanically harvested lettuce in both the pallet-size bin and in the jumble-filled box had less trim loss than hand-harvested, hand-packed lettuce in the conventional cartons (table 5).

Firmness and appearance of the lettuce on arrival was about the same for both methods of harvesting and packing and for all three containers tested. There was slightly more crushing and bruising of mechanically harvested, jumble-filled lettuce than of hand-harvested lettuce packed in the conventional carton.

TABLE 5.—*Arrival condition of mechanically harvested lettuce jumble filled in large containers and in bins and hand-harvested lettuce place packed in cartons at midwestern markets, 1974*

Item	Jumble-filled experimental pallet bin	Jumble-filled experimental nonwaxed box	Place-packed conventional carton
Appearance rating [1]	3.3	3.3	3.3
Gross weight (pounds per head)	1.8	2.0	2.2
Net weight (pounds per head after trim)	1.5	1.6	1.7
Trim loss (percent)	16.7	20.0	22.7
Firmness rating [2]	3.9	4.1	3.9
Crushing and bruising rating [3]	1.7	1.7	1.5

[1] 1 = unsalable, 2 = poor, 3 = fair, 4 = good, 5= excellent.
[2] 1 = soft, 2 = fairly firm, 3 = firm, 4 = hard, 5= extra hard.
[3] 1 = none, 2 = slight, 3 = moderate, 4 = severe, 5= extreme.

CONCLUSIONS

Mechanically harvested lettuce, jumble filled into containers larger than the conventional 24-head cartons, can be shipped to eastern and midwestern markets and arrive in comparable condition to lettuce packed in the 24-head cartons. Although these larger containers were 23 and 24 inches deep, earlier laboratory tests conducted by Stout and others [4] indicated that lettuce can be handled in bins 4 or 5 feet deep without excessive damage.

The primary problem was how to efficiently handle the large volume of lettuce the USDA prototype harvester delivers. It was difficult to make, close, and stack the experimental, jumble-filled boxes on the harvester. It was equally difficult to make the experimental pallet-size bins on the harvester. Removing the packed experimental boxes and bins, either by hand or by fork truck, required a considerable amount of time. A great deal of expertise was required to remove the experimental bins with a fork truck because of the unevenness of the ground in lettuce fields.

One possible solution to these handling problems might be to convey the harvested lettuce to a separate vehicle that follows or parallels the harvester. This unit might have the capability of making, filling, closing, and accumulating the packed boxes.

A second alternative might be to convey the lettuce from the harvester into a trailer, which would be taken to a central packing plant. Hinds and others [5] found in their survey of supermarkets that receivers would prefer more uniform quality. Centralized lettuce packing might accomplish this result.

Future marketing research on Western iceberg lettuce should concentrate on: (1) Evaluating a new size lettuce carton suitable for unitizing and hand stacking in present transportation equipment, (2) evaluating the use of various types and sizes of pallets and slipsheets for unitized handling, and (3) developing a handling system compatible with the mechanical lettuce harvester.

[4] STOUT, B. A., KASMIRE, R. F., and RUBATZKY, V. E. BULK BIN HANDLING OF CRISPHEAD LETTUCE. Amer. Soc. Agr. Engin. Trans. 16(1) :62-63. 1973.

[5] HINDS, R. H., HINSCH, R. T., RIJ, R. E., and HARRIS, C. M. ICEBERG LETTUCE HANDLING AND MARKETING SYSTEMS SURVEY. U.S. Dept. Agr., Agr. Res. Serv. Rpt. April 1974. (Unpublished.)

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